



# Advances in health economics & data science

Dr. Robert Smith

Lumanity Knowledge Series

31st May 2023



University of  
Sheffield



# Who are we anyway?



Dr. Paul Schneider



Dr. Robert Smith



Dr. Sarah Bates



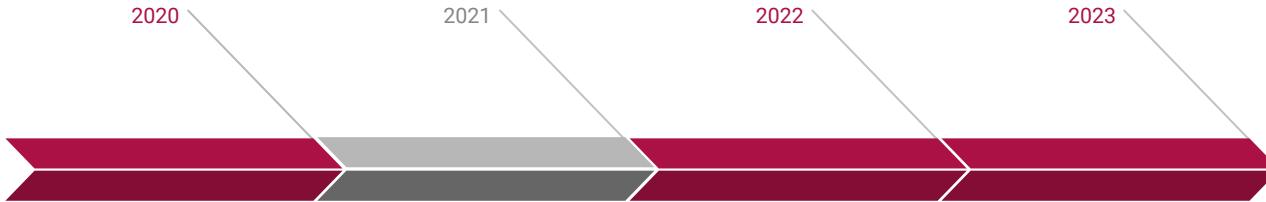
ShangShang Gu



Wael Mohammed



# Topic Timeline



## Making Health Economic Models Shiny: A tutorial

**Smith RA and Schneider PP.** Making health economic models Shiny: A tutorial. *Wellcome Open Res* 2020, **5**:69 (<https://doi.org/10.12688/wellcomeopenres.15807.2>)

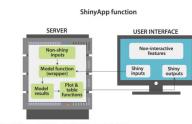
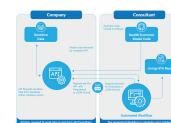


Figure 1: Diagram depicting how the Shiny-icker app is structured.

## COVID-chaos

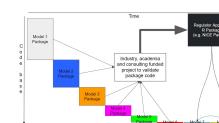
## Living HTA: Automating Health Economic Evaluation with R

**Smith RA, Schneider PP and Mohammed W.** Living HTA: Automating Health Economic Evaluation with R. *Wellcome Open Res* 2022, **7**:194 (<https://doi.org/10.12688/wellcomeopenres.17933.2>)



## R Packages for health economic evaluation: A tutorial

**Smith RA, Schneider PP and Mohammed W.** R Packages for health economic evaluation: A tutorial. Submitted to *Wellcome Open Res* 2023.





# MS Excel vs R (python / others)



			Comments	Link to Slide
1	Familiarity Barriers to entry	●●●●●	● Coding in R is hard	<a href="#">Teaching</a>
2	Capabilities	●●	●●●●● ... but much more powerful	<a href="#">Comparison</a>
3	Computational Speed	●	●●●● ... and faster	<a href="#">Benchmark</a>
4	Development & Iteration speed	●●	●●●● ... and easier to develop at scale	<a href="#">Living HTA</a>
5	Transparency	●●	●●●●● ... and more robust (int. & ext. review)	<a href="#">Packages: Data/model</a>
6	Engagement & Visualisation	●●●	●●●●● ... and looks better	<a href="#">Shiny UI</a>

An entirely personal, and very biased set of estimates!



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# Upskilling

**Section added to the site with Tutorials!**

We have added a new section to the website, with a view of collating tutorials on tools for economic evaluation based on R. The first one is an online tutorial on creating a Shiny interface for Markov models by Robert Smith and Paul Schneider from University of Sheffield. Shiny allows you to create user friendly and web-accessible graphical user interfaces for your R models. More details [here](#)\*

**Mission**

R for Health Technology Assessment (HTA) is an academic consortium whose main objective is to explore the use of R for cost-effectiveness analysis (CEA) as an alternative to less efficient, generalisable and powerful software such as spreadsheets. R is a freely available language and environment for statistical computing and graphics which provides a wide variety of statistical and graphical techniques. We advocate the use of proper statistical software, notably R, to be used in the whole process of health economic evaluation.

General topics of interest include a wide range of technical aspects, e.g. the discussion of the many available R add-on packages, as well as ways to help users get the most out of R for CEA. Presentations and public discussions are used to address the computational and transparency advantages of R over Excel for CEA and for easing collaboration. Our members have diverse experience in government (including NICE in the UK), academia, and industry.

**Tweets from @rhta16**

- Gianluca Baio (@gianluca\_baio) - May 16 Coding programme. Looking forward to it!
- r-hta (@rhta16) - May 16 Check out the programme for our next R-HTA workshop 8, 9, 10 June!
- UCI Statistical Science (@stats\_UCL) - May 9

<https://r-hta.org/>

## Building Health Economic Models in R

**8 Automated Reporting**

### 8.1 Background

One of the benefits of building models in R is that we can write code to generate reports based on the inputs and outputs of our model. This was a crucial part of our proposed transition of the health economic evaluation pipeline towards something that looks like this:

New pipeline

This section guides the reader through the process of writing such a report using two R packages, `markdown` (for a PDF document) and `officeR` (for a Powerpoint presentation). Both packages are able to output in a large number of formats.

We show how to write these reports in such a way to be functional and aesthetically pleasing, and show how to write a single script which runs a health economic model and then renders a PDF or set of Powerpoint slides using the parameters and results of

**On this page**

- 8.1 Automated Reporting
- 8.2 Automating R
- 8.2.1 Back
- 8.2.1.1 R
- 8.2.1.2 RMark
- 8.2.3.1 R
- 8.2.4 In
- 8.2.5 G
- 8.2.6 C
- 8.2.7 A
- 8.2.8 T
- 8.2.9 C
- 8.2.10 Case Studies
- 8.3 Office
- 8.3.1 Creating .pptx files
- 8.3.2 E
- 8.3.3 C
- 8.4 Automation
- 8.4.1 R
- 8.4.2 N
- 8.4.3 D
- 8.5 Solutions
- 8.5.1 R
- 8.5.2 C

<https://darkpeakanalytics.com/>



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# If statistics programs/languages were cars ...





# MS Excel vs R (python / others)



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# Computational speed

	R	Excel
Average Time (seconds) required for 10,000 simulations	31.8	872.7

27x faster

Hollman, C., Paulden, M., Pechlivanoglou, P. and McCabe, C., 2017. A comparison of four software programs for implementing decision analytic cost-effectiveness models. *Pharmacoeconomics*, 35(8), pp.817-830.



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# Living HTA

PharmacoEconomics (2023) 41:227–237  
<https://doi.org/10.1007/s40273-022-01229-4>

**LEADING ARTICLE**

**Check for updates**

**Living Health Technology Assessment: Issues, Challenges and Opportunities**

Praveen Thokala<sup>1</sup> · Tushar Srivastava<sup>1,2</sup> · Robert Smith<sup>1,3</sup> · Shijie Ren<sup>1</sup> · Melanie D. Whittington<sup>4</sup> · Jamie Elvidge<sup>5</sup> · Ruth Wong<sup>1</sup> · Lesley Uttley<sup>1</sup>

Accepted: 4 December 2022 / Published online: 18 January 2023  
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**Abstract**  
 Health technology assessments (HTAs) are typically performed as one-off evaluations and can potentially become out-of-date due to the availability of new data, new comparators, or other factors. Recently, living approaches have been applied to systematic reviews and network meta-analyses to enable evidence syntheses to be updated more easily. In this paper, we provide a definition for ‘Living HTA’ where such a living approach could be applied to the entire HTA process. Living HTA could involve performing regular or scheduled updates using a traditional manual approach, or indeed in a semi-automated manner leveraging recent technological innovations that automate parts of the HTA process. The practical implementation of living HTA using both approaches (i.e., manual approach and using semi-automation) is described along with the likely issues and challenges with planning and implementing a living HTA process. The time, resources and additional considerations outlined may prohibit living HTA from becoming the norm for every evaluation; however, scenarios where living HTA would be particularly beneficial are discussed.

**Key Points for Decision Makers**

Health technology assessments (HTAs) are typically performed as one-off evaluations and can quickly become out-of-date.

Living HTA approaches can ensure that the HTAs are up-to-date, and potentially living HTAs could be updated manually or (semi-)automatically using innovative software platforms.

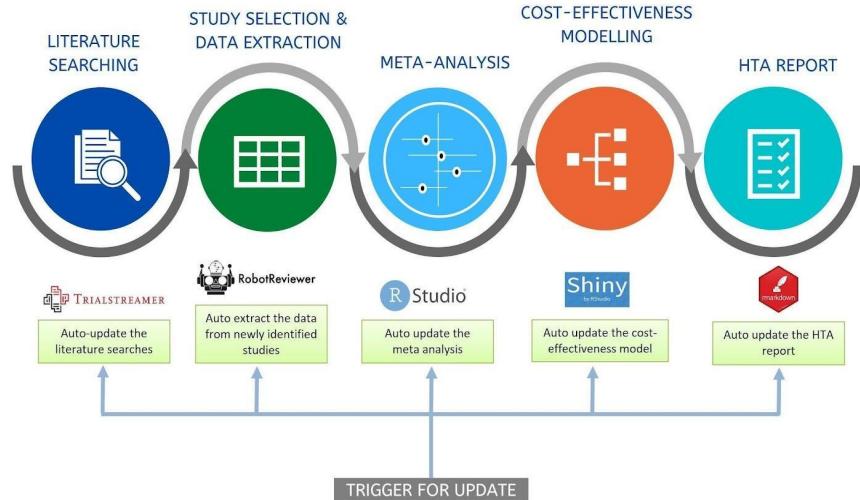
However, living HTA involves substantial time, planning and resource commitments, and as such should only be used in situations where it is important to ensure the HTA is up-to-date.

**1 Introduction**

Health technology assessment (HTA) agencies perform evaluation of clinical and cost-effectiveness evidence of new interventions to decide whether they should be reimbursed.

Extended author information available on the last page of the article

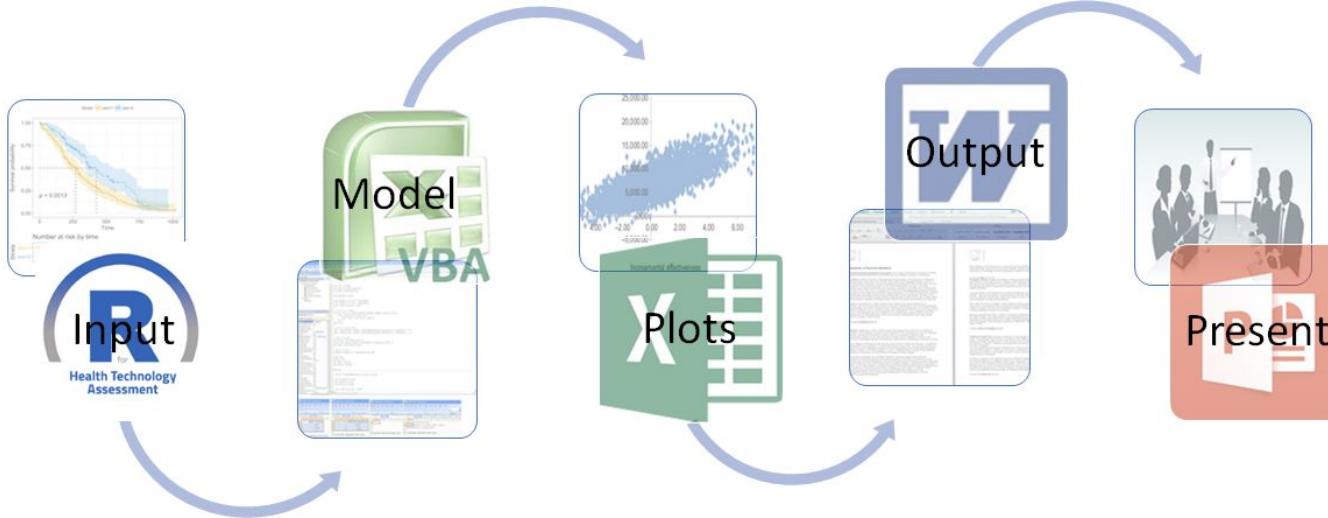
**Figure 3: Potential example living HTA using (semi-)automation**



Thokala, P., Srivastava, T., **Smith, R.**, Ren, S., Whittington, M.D., Elvidge, J., Wong, R., Uttley, L. (2023). Living Health Technology Assessment – Issues, Challenges and Opportunities. *Pharmacoeconomics*.

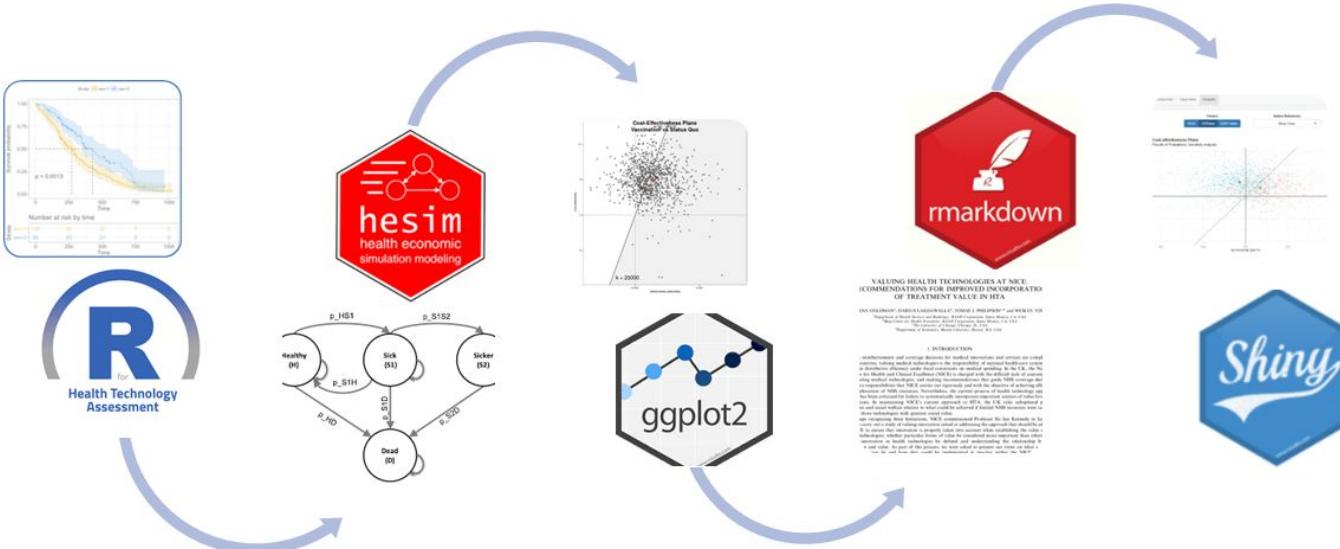


# Current process





# Future process





# Living HTA

Wellcome Open Research

Wellcome Open Research 2022, 7:194 Last updated: 24 OCT 2022

METHOD ARTICLE

## REVISED Living HTA: Automating Health Economic Evaluation

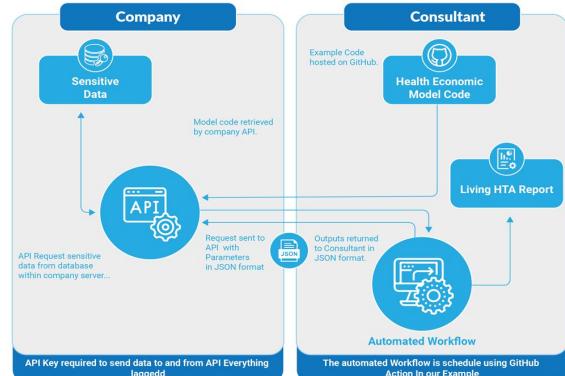
with R [version 2; peer review: 2 approved]

Robert A. Smith<sup>1,2</sup>, Paul P. Schneider<sup>1,3</sup>, Wael Mohammed<sup>1,3</sup>

<sup>1</sup>School of Health and Related Research, University of Sheffield, Sheffield, S1 4DA, UK

<sup>2</sup>Luminary, Sheffield, S1 2GO, UK

<sup>3</sup>Dark Peak Analytics, Sheffield, S11 7BA, UK



**Smith RA, Schneider PP and Mohammed W.** Living HTA: Automating Health Economic Evaluation with R. *Wellcome Open Res* 2022, 7:194 (<https://doi.org/10.12688/wellcomeopenres.17933.2>)

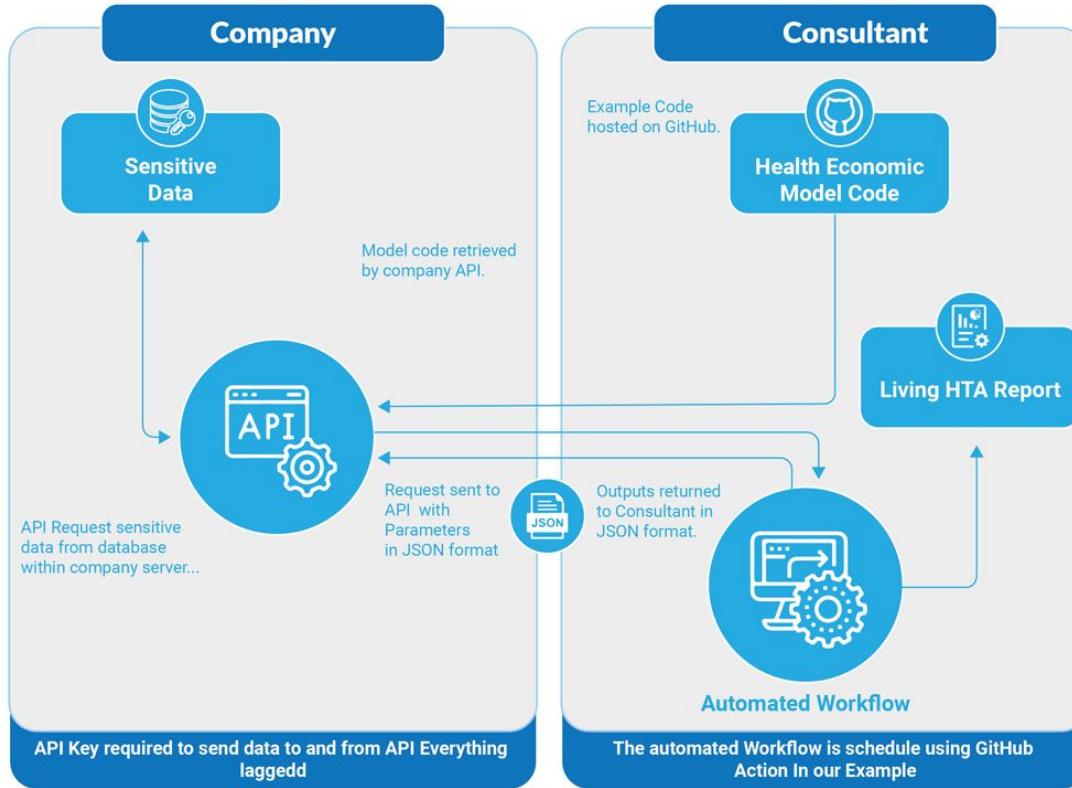
The screenshot shows a shiny app interface titled 'Living HTA - Demo Shiny App'.

- Navigation:** Includes links for 'Introduction', 'The model', 'Report', and 'Information'.
- Content:**
  - A note: 'This example application was created for the R-HTA workshop, held at Oxford University on Thursday 18th May 2022.'
  - A note: 'This app showcases the methods described in Smith, Schneider & Mohammed (2022).'
  - A note: 'The API Key is the doi of the paper: <https://doi.org/10.12688/wellcomeopenres.17933.2>'
  - The main title: 'Living HTA: Automating health economic evaluation with GitHub Actions & plumber APIs'
  - Author information: 'Robert Smith<sup>1,2</sup>, Paul Schneider<sup>1,3</sup> & Wael Mohammed<sup>1,3</sup>'
  - Footnotes: '1 University of Sheffield, Sheffield, UK', '2 Luminary, Sheffield, UK', '3 Dark Peak Analytics, Sheffield, UK.'
  - Background:** A note about the process of updating economic models.
  - Methods:** A note about the automated analysis and reporting pipeline.
  - Results & Discussion:** A note about the method being relatively complex but allowing for automated reporting.
  - Why does this matter?** A question at the bottom left.
  - Attribution:** 'By Robert - Paul, Wael & Zauar' at the bottom right.

[https://darkpeakanalytics.shinyapps.io/living\\_HTA\\_demo/](https://darkpeakanalytics.shinyapps.io/living_HTA_demo/)



# Living HTA





# MS Excel vs R (python / others)

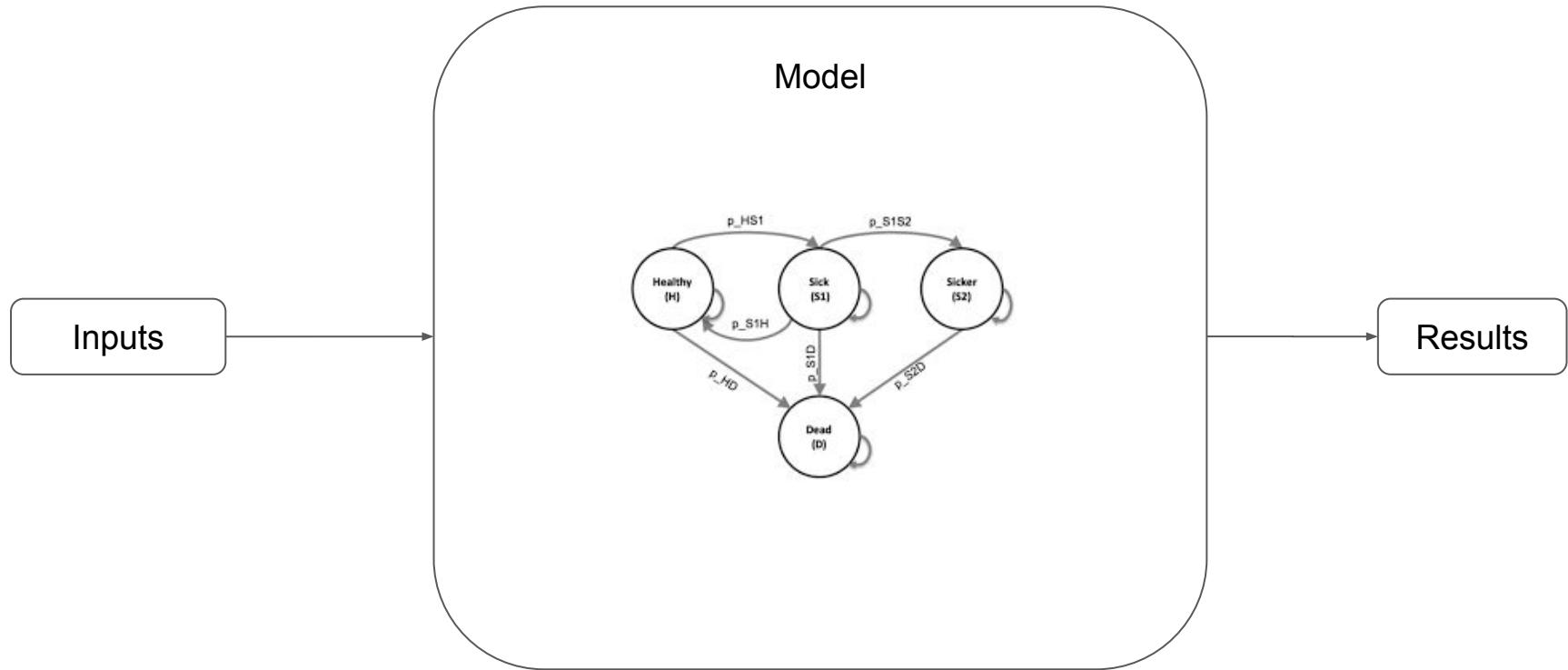


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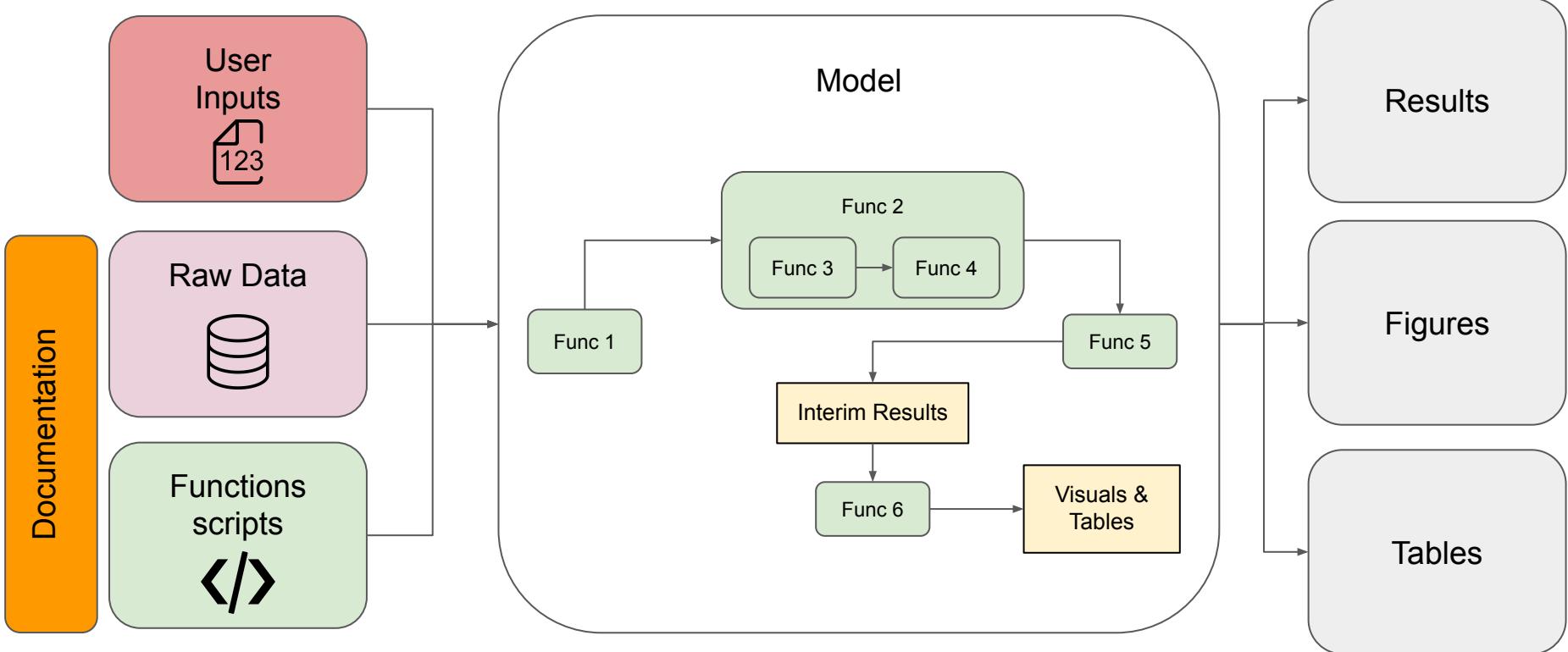


# Building a model in R



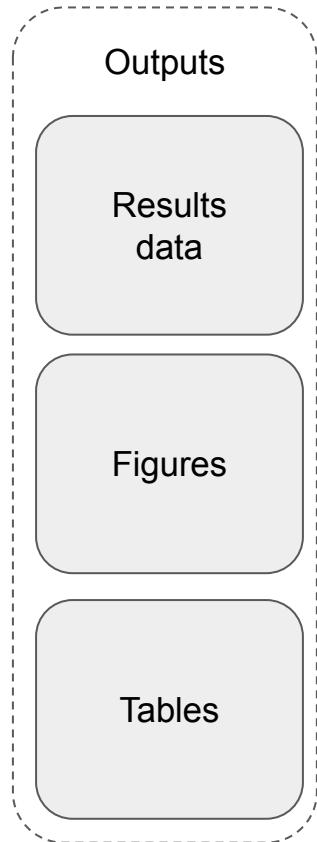
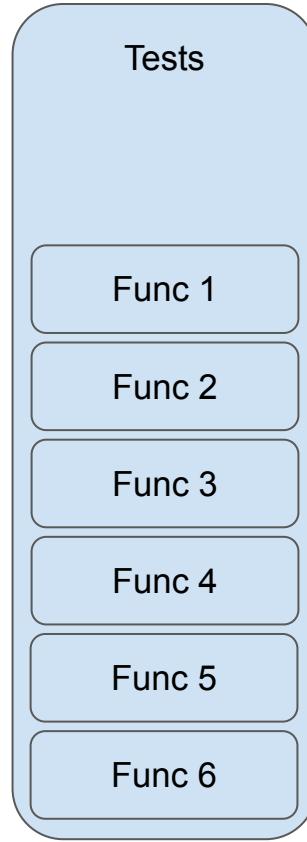
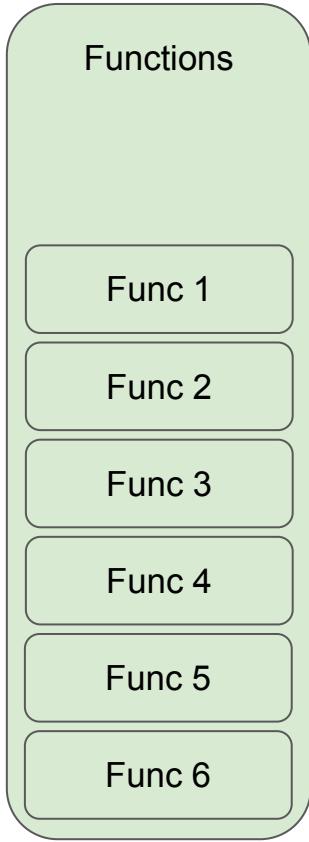
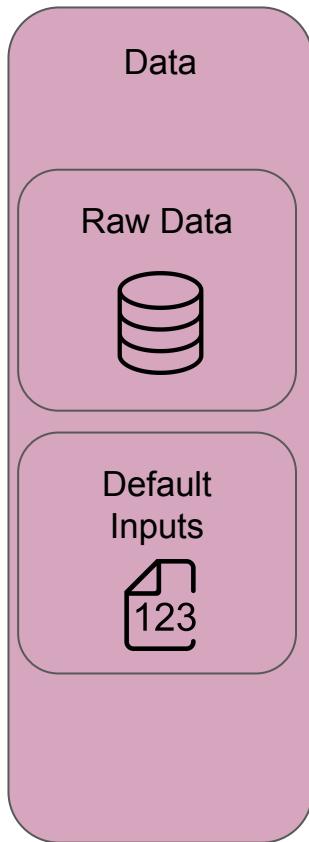


# Building a model in R





# Building a model in R



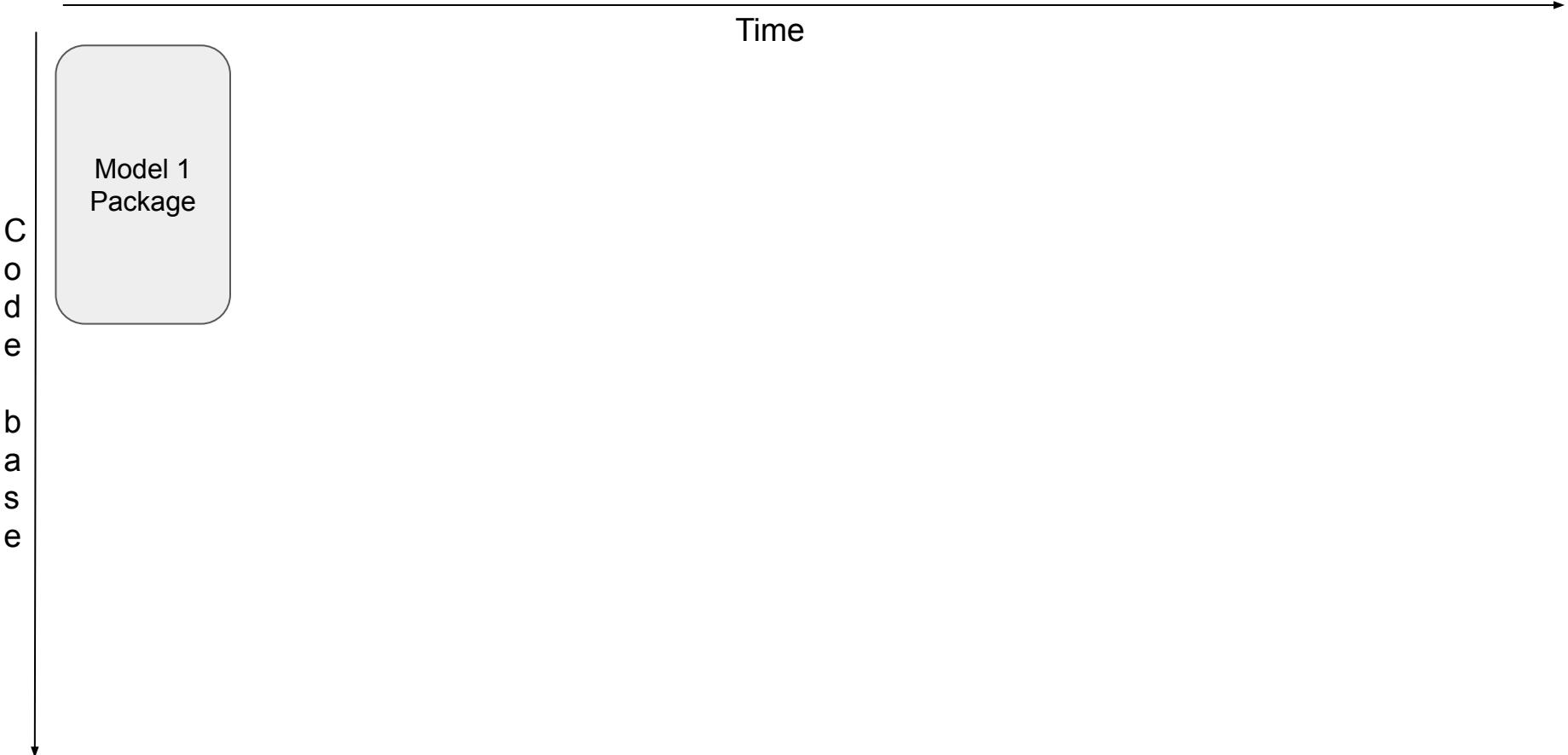


# Benefits of using a Package vs non-packaged code.

1. Every Package will have a similar structure
  - a. Improves familiarity with models.
2. Documentation by default
  - a. Vignettes to show how the package works (walking the user through the code).
  - b. Roxygen comments on every function (exactly what is it doing)
3. Unit testing is built-in
  - a. Testing gives modeller confidence in their methods.
  - b. Testing allows reviewers to 'test the tests' rather than from scratch.
4. Functions are more easily distributed (e.g. `install_github("your-package")`)
  - a. Therefore don't have to continually re-invent wheels
  - b. Standardisation (pros and cons)
  - c. Validation (easier to review, more confidence)



# Benefits of using a Package vs non-packaged code.



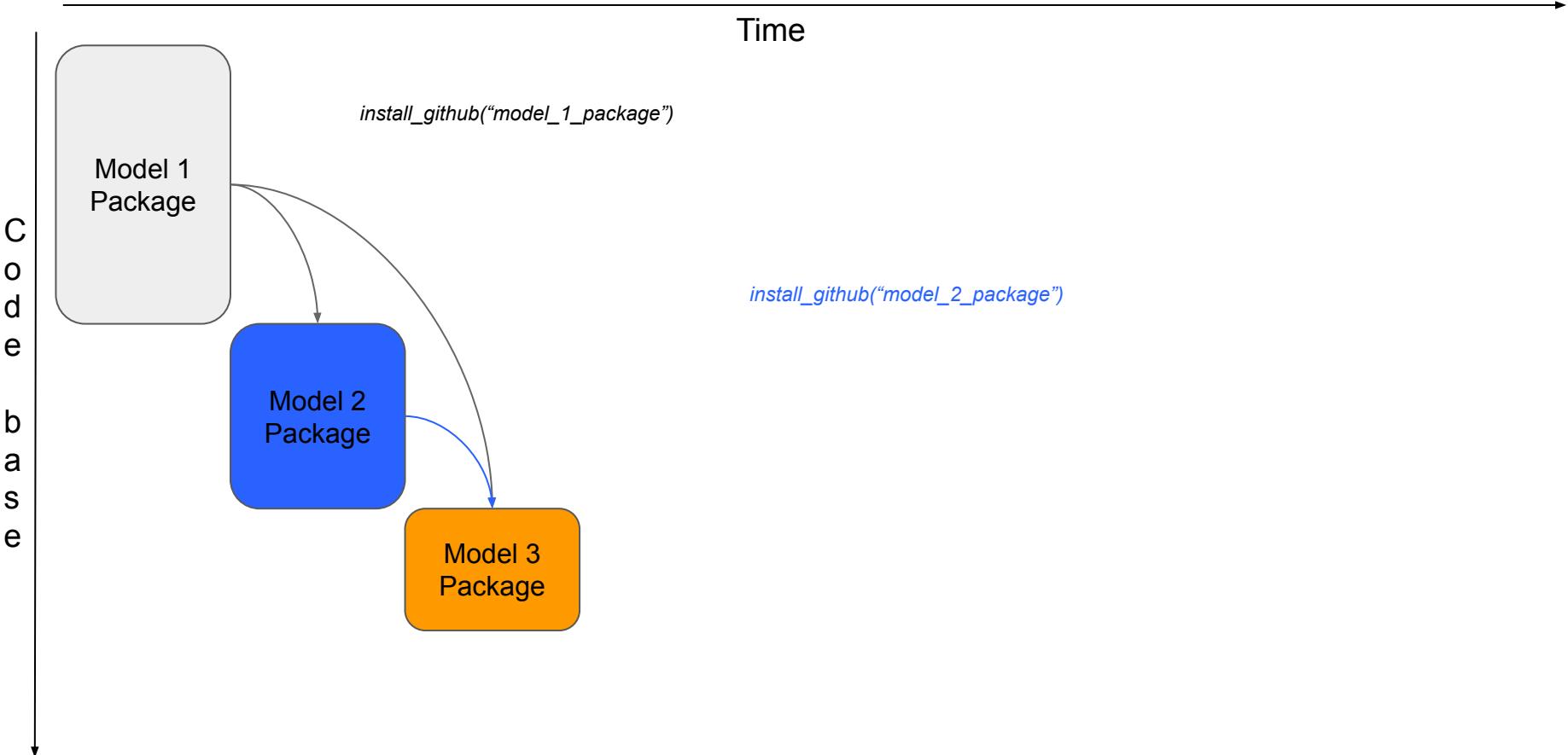


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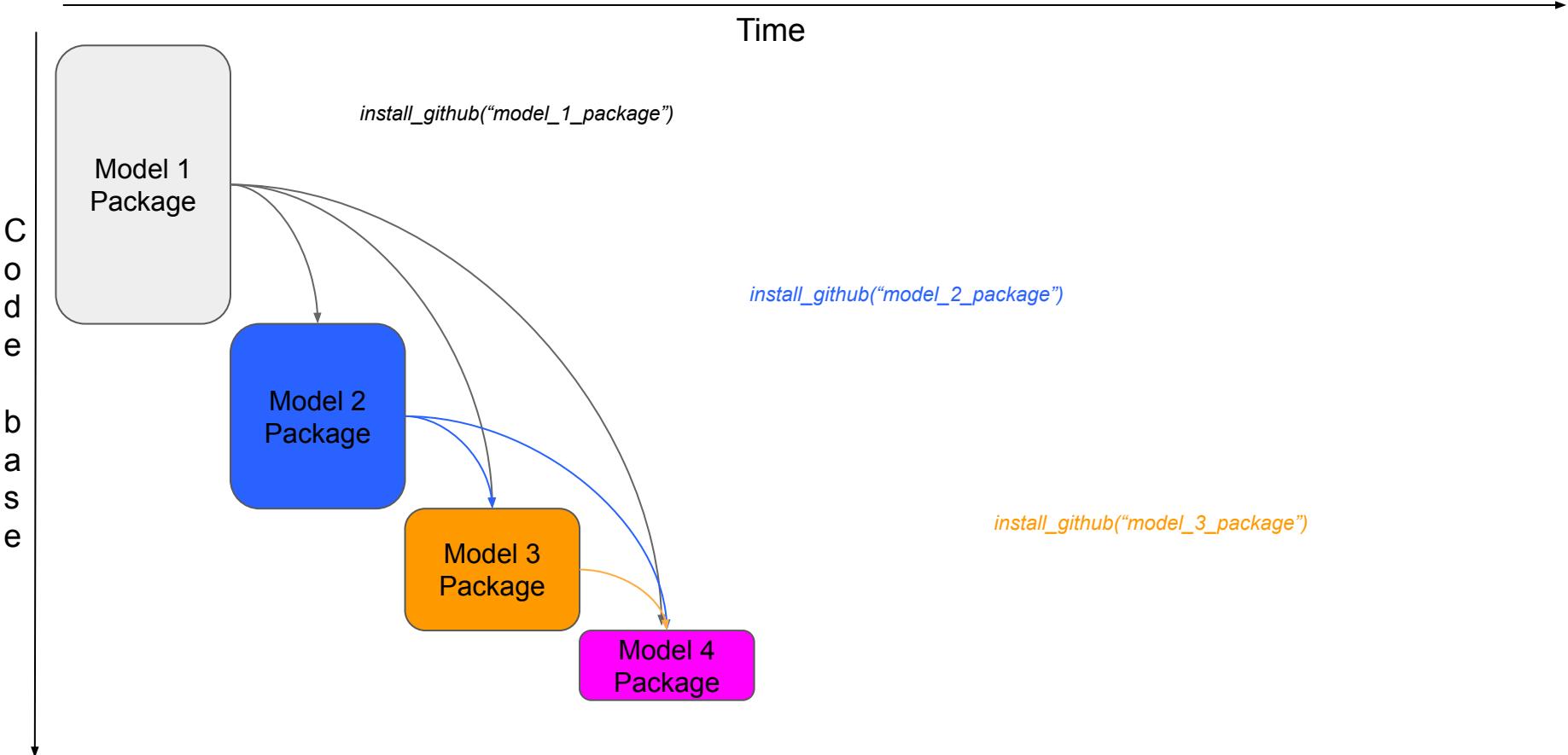


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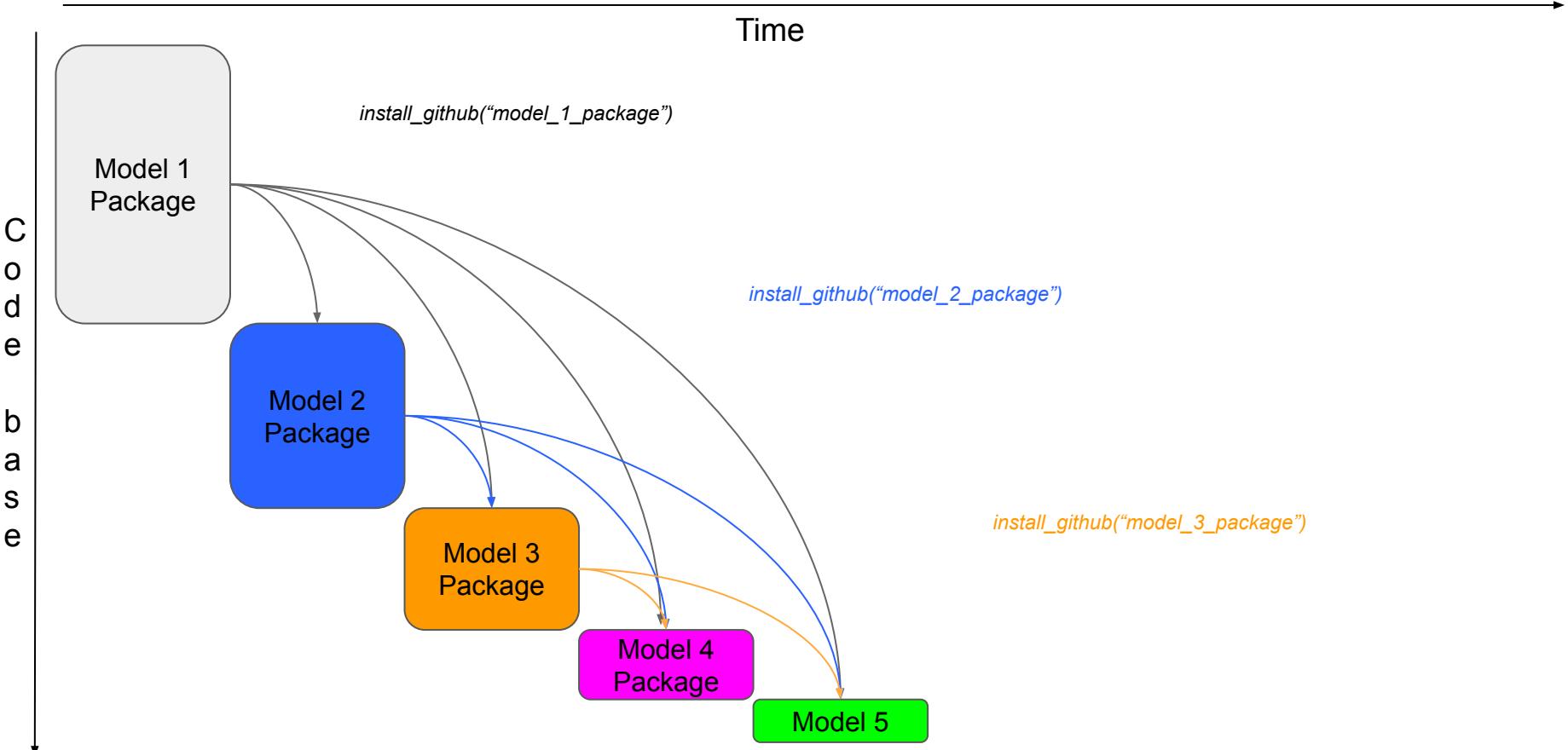


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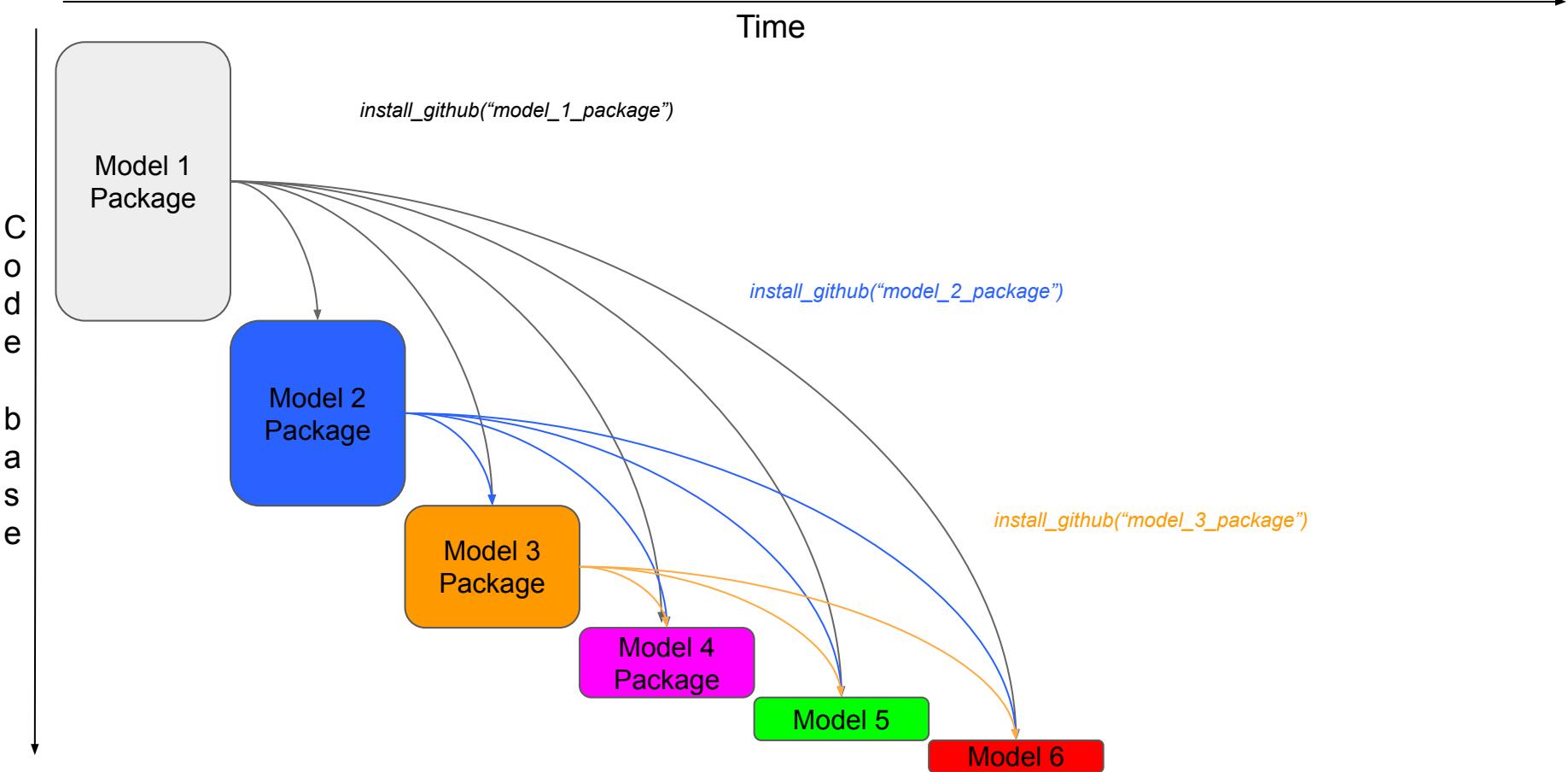


# Benefits of using a Package vs non-packaged code.





# Benefits of using a Package vs non-packaged code.





# Benefits of using a Package vs non-packaged code.

*“But won’t we end up having to install  
a large number of packages, just to  
get one or two functions from each?”*

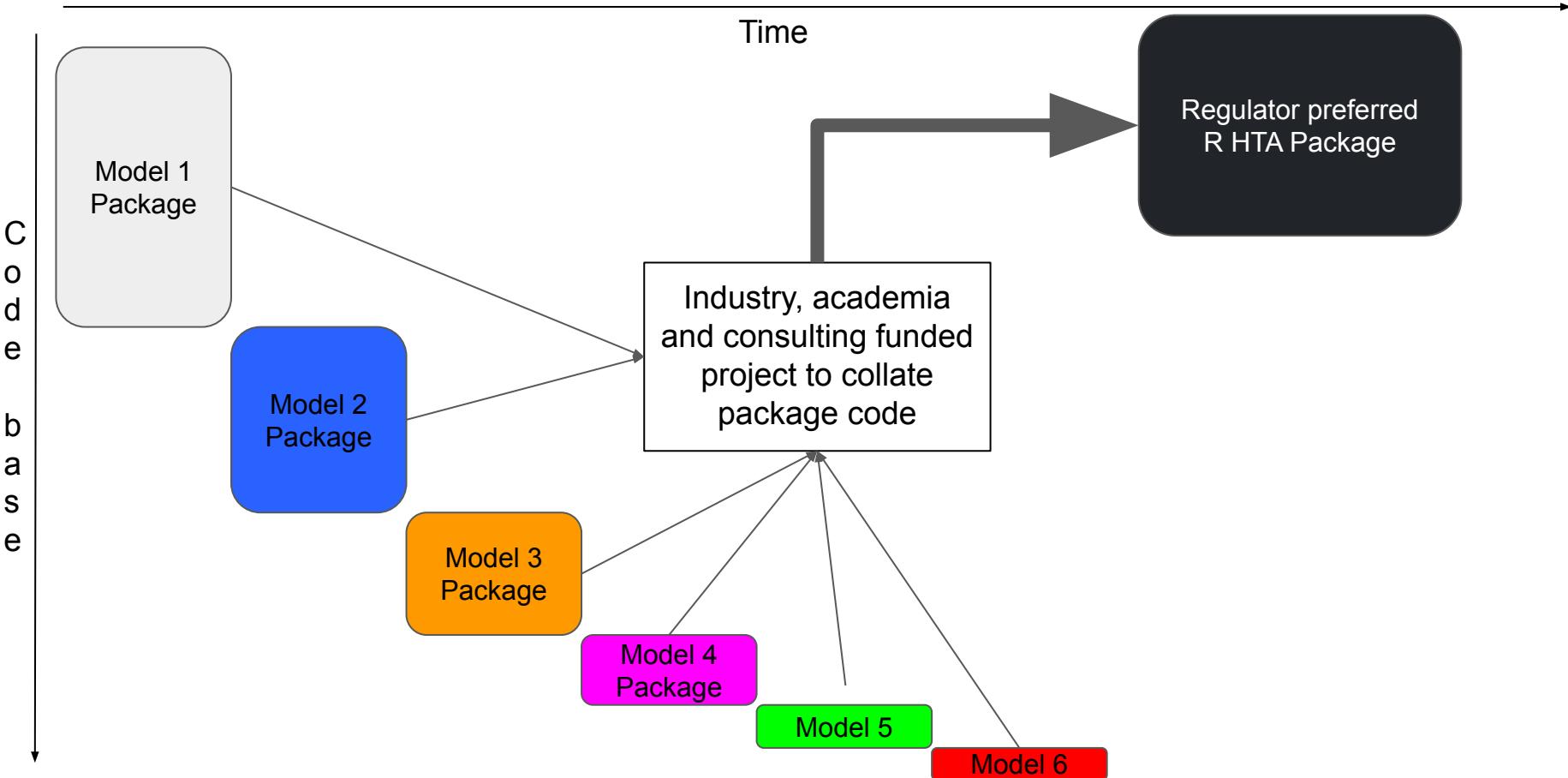
*Anon*



Large package, small function ...

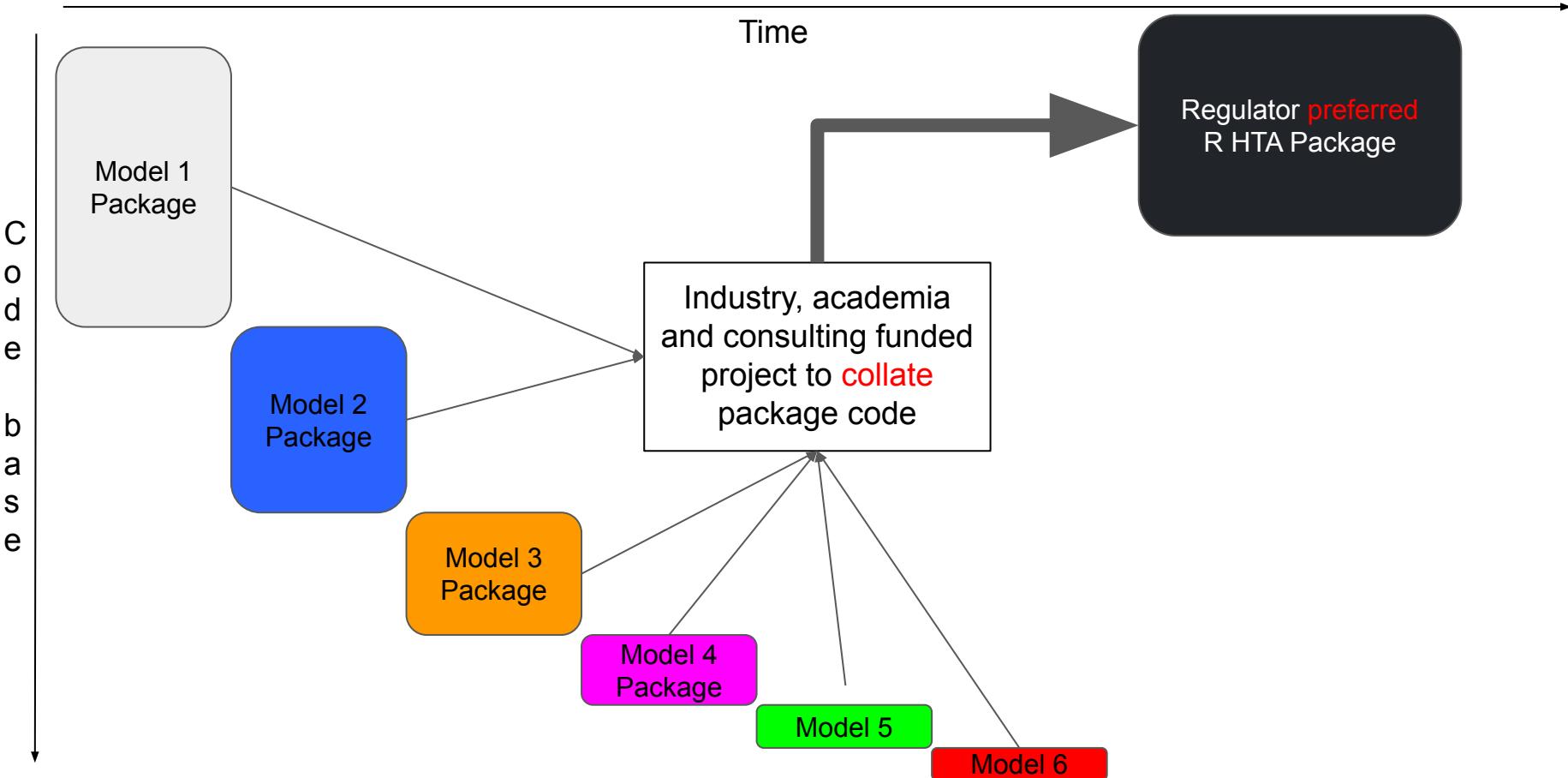


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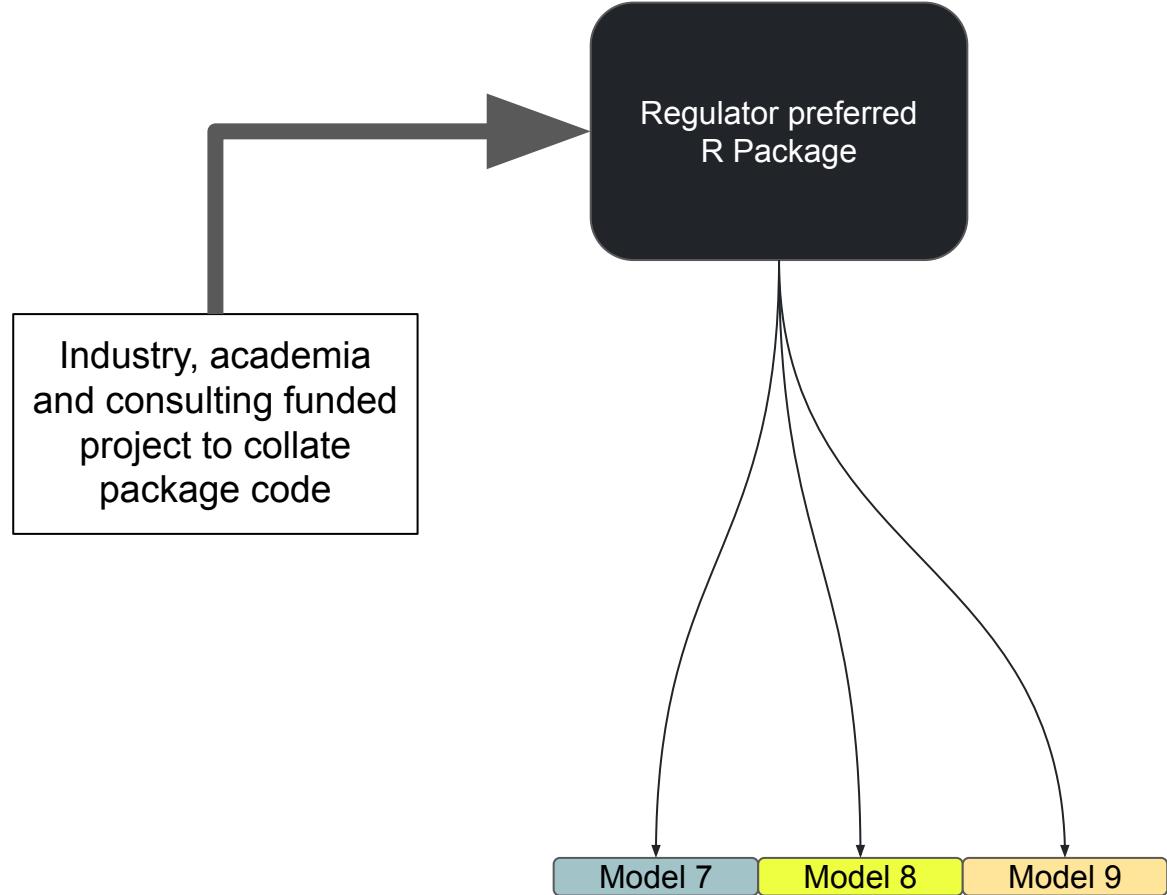


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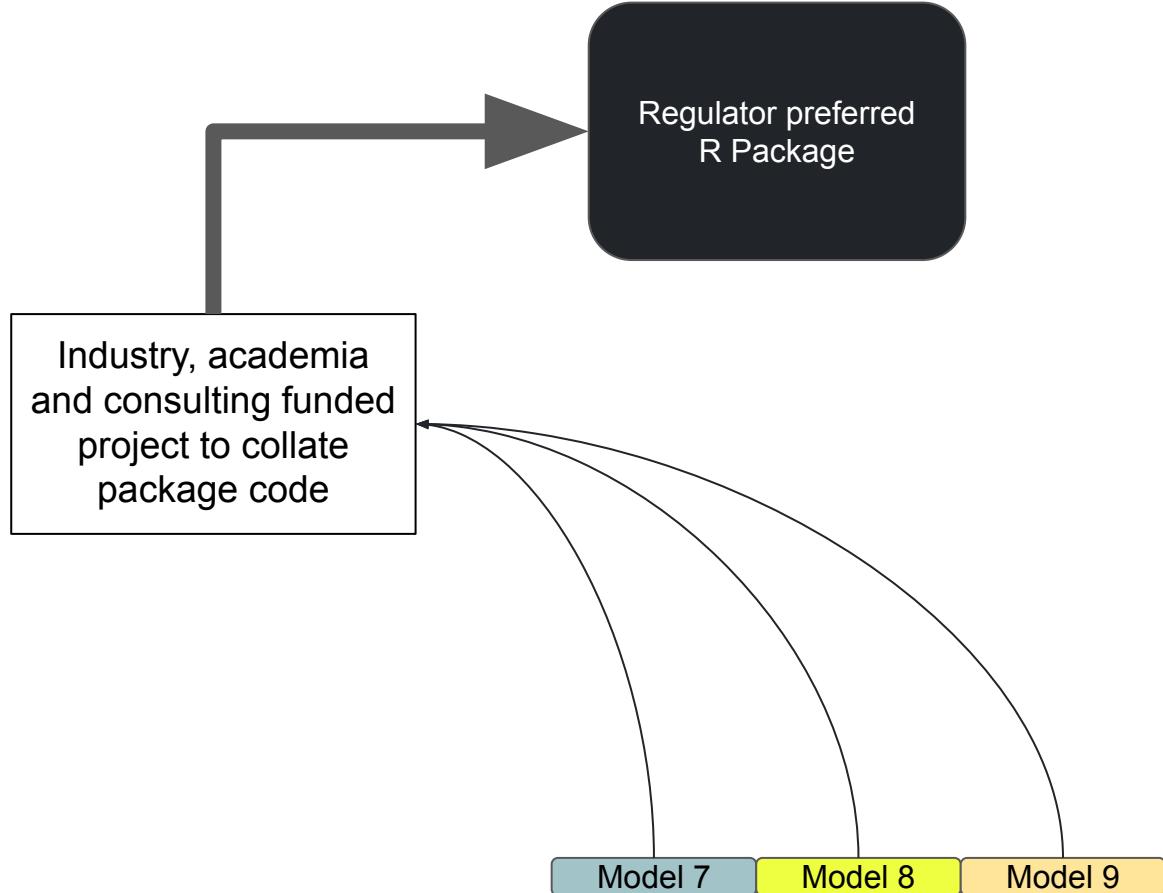


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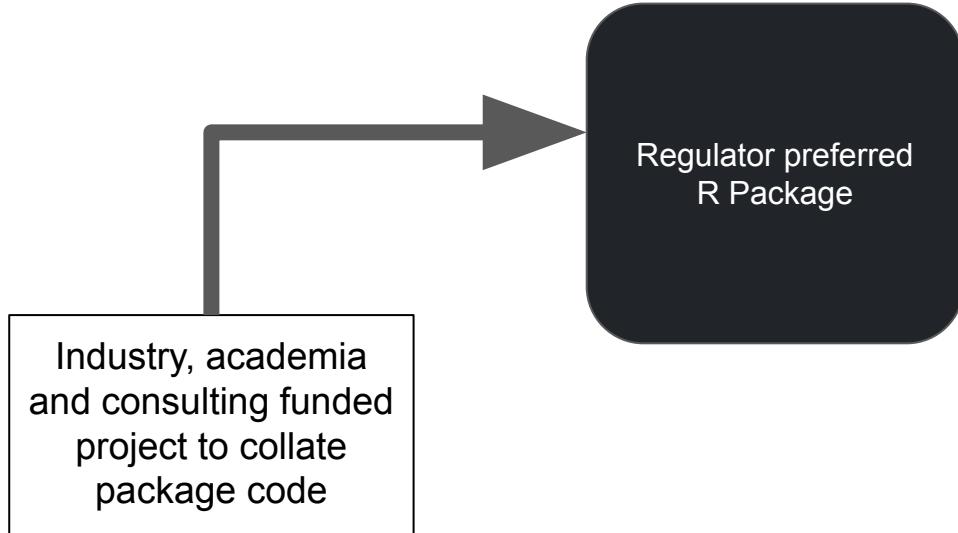


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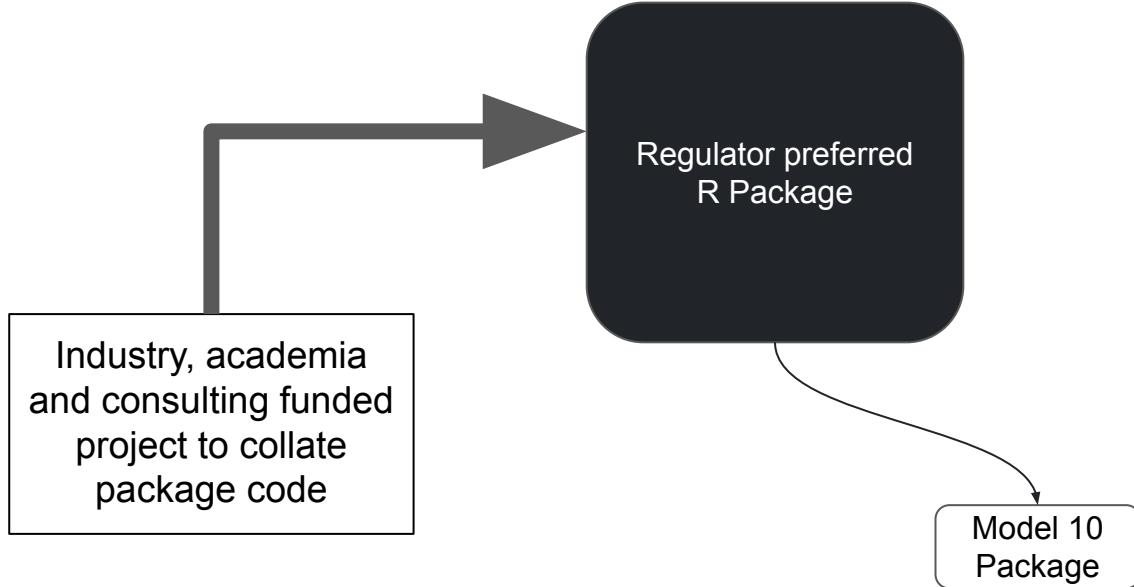


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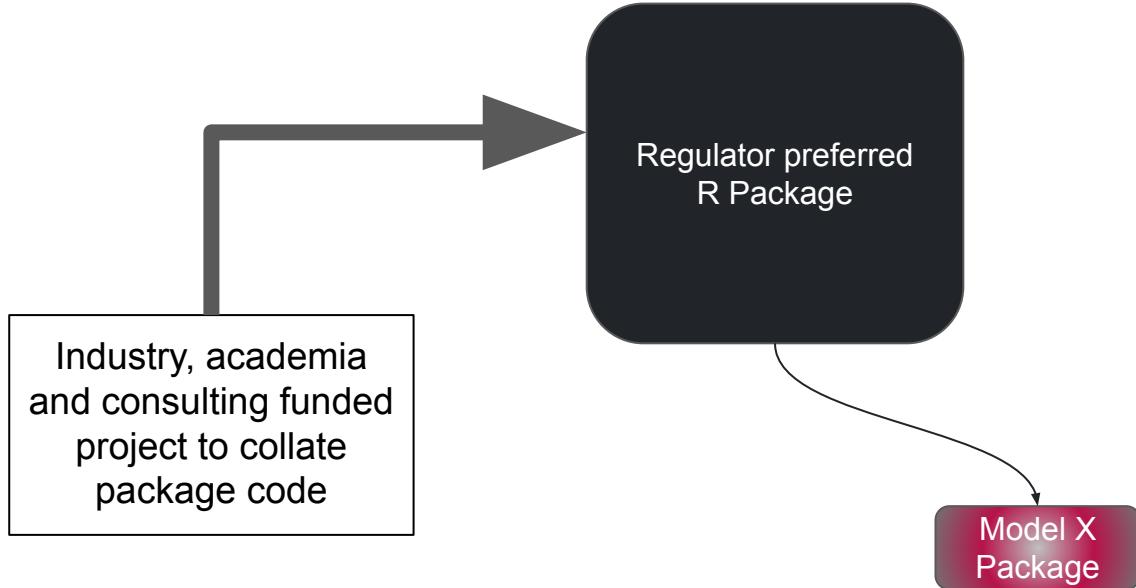


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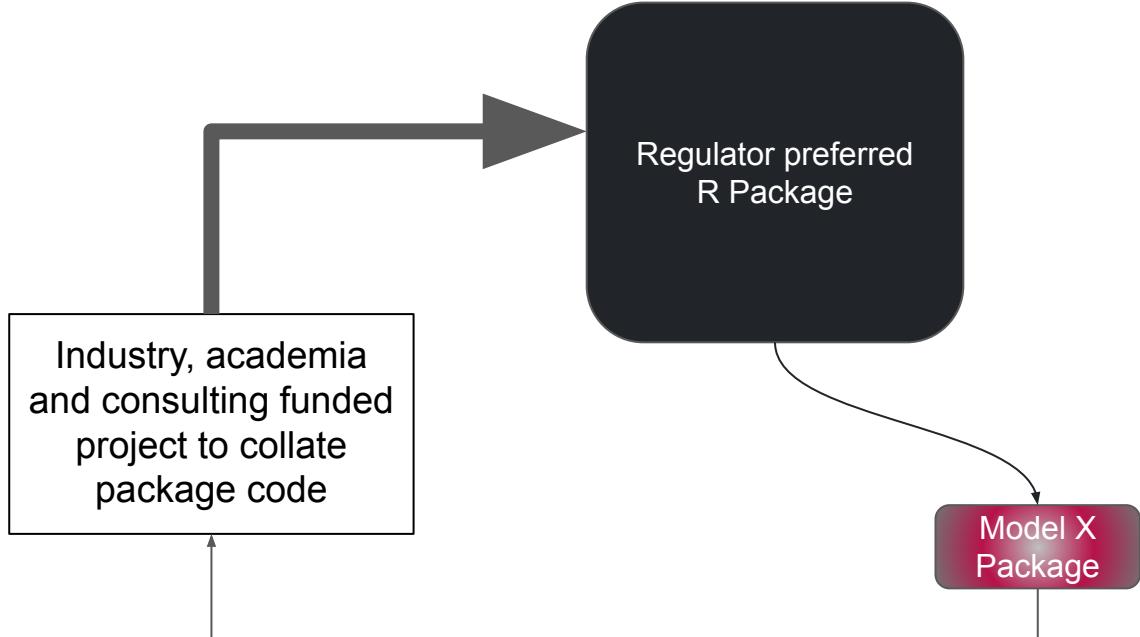


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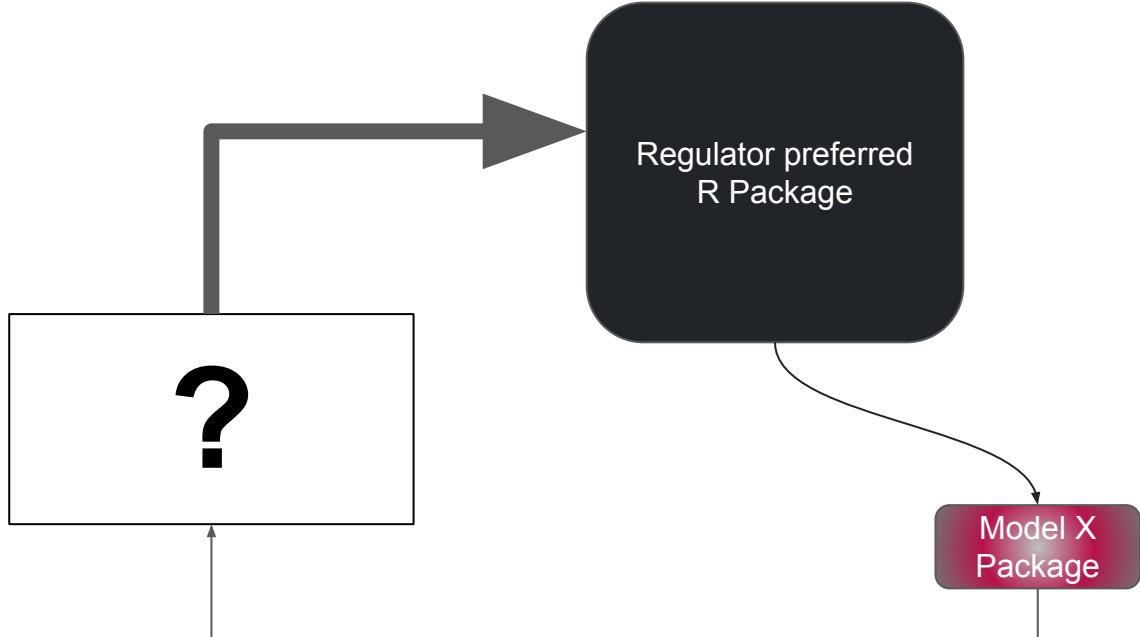


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# Benefits of using a Package vs non-packaged code.





# Packaging cost-effectiveness models in R: A tutorial

Wellcome Open Research Wellcome Open Research 2016 - DRAFT ARTICLE (PRE-SUBMISSION)

## Packaging cost-effectiveness models in R: A tutorial.

Robert A. Smith<sup>1,2</sup>, Wael Mohammed<sup>1,2</sup>, and Paul P. Schneider<sup>1,2</sup>

<sup>1</sup>School of Health and Related Research, University of Sheffield, Sheffield, S1 4DA, UK  
<sup>2</sup>Dark Peak Analytics, Sheffield, S11 7BA, UK

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**Abstract**

**Background:** The growing use of programming languages like R in health economics and decision science has numerous benefits, such as reducing errors, improving transparency, and aiding review. However, there is limited guidance on how to best develop models using R and no clear consensus has emerged. **Methods:** We present the benefits of creating health economic model Packages—structured collections of functions, data sets, tests, and documentation. Assuming an intermediate understanding of R, we provide a tutorial to show how to build a basic R Package and describe a case study in which we build an R Package for an existing teaching model coded in R. Both sets of code are made available open source. **Results:** We show that R Packages facilitate documentation and unit testing, simplifying review and validation of health economic evaluation models. They promote code distribution and reuse, streamlining model development, and improving the code base in health economics and decision science. By minimizing code duplication and providing a standardised approach to handling data, Packages could enhance efficiency in the development of new models. We explore potential avenues for Package validation, including formal processes involving peer review or certification, and open source community validation. **Conclusion:** R Packages offer a valuable framework for enhancing the quality, efficiency, and transparency of health economic evaluation models. By embracing R Packages and fostering a collaborative culture, the health economics community can improve decision making and resource allocation in healthcare.

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**Keywords**

R, Packages, HTA, Health Economics, Open-source

Smith, R.A., Mohammed, W. and Schneider, P.P. (2023). Packaging cost-effectiveness models in R: A tutorial.

[Draft paper currently under review in GoogleDoc](#)



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**Background:** The growing use of programming languages like R in health economics and decision science has numerous benefits, such as reducing errors, improving transparency, and aiding review. However, there is limited guidance on how to best develop models using R and no clear consensus has emerged. **Methods:** We present the benefits of creating health economic model Packages—structured collections of functions, data sets, tests, and documentation. Assuming an intermediate understanding of R, we provide a tutorial to show how to build a basic R Package and describe a case study in which we build an R Package for an existing teaching model coded in R. Both sets of code are made available open source. **Results:** We show that R Packages facilitate documentation and unit testing, simplifying review and validation of health economic evaluation models. They promote code distribution and reuse, streamlining model development, and improving the code base in health economics and decision science. By minimizing code duplication and providing a standardised approach to handling data, Packages could enhance efficiency in the development of new models. We explore potential avenues for Package validation, including formal processes involving peer review or certification, and open source community validation. **Conclusion:** R Packages offer a valuable framework for enhancing the quality, efficiency, and transparency of health economic evaluation models. By embracing R Packages and fostering a collaborative culture, the health economics community can improve decision making and resource allocation in healthcare.

**Keywords**  
R, Packages, HTA, Health Economics, Open-source

This bit sucks ... here's how to make it better!

(P.S. Make me a coauthor please)



# MS Excel vs R (python / others)

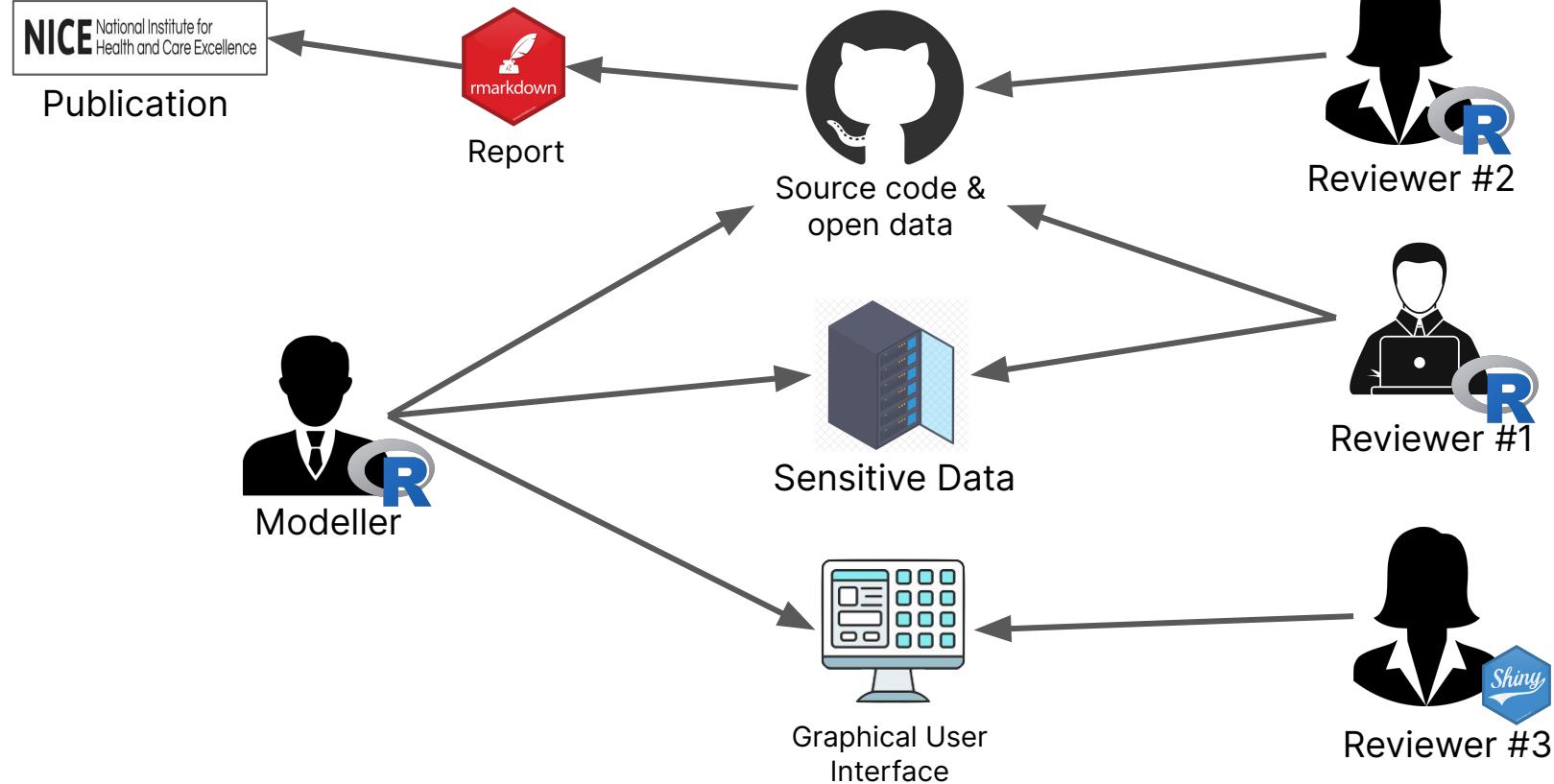


			Comments	Link to Slide
1	Familiarity Barriers to entry	●●●●●	● Coding in R is hard	<a href="#">Teaching</a>
2	Capabilities	●●	●●●●● ... but much more powerful	<a href="#">Comparison</a>
3	Computational Speed	●	●●●● ... and faster	<a href="#">Benchmark</a>
4	Development & Iteration speed	●●	●●●● ... and easier to develop at scale	<a href="#">Living HTA</a>
5	Transparency	●●	●●●●● ... and more robust (int. & ext. review)	<a href="#">Packages: Data/model</a>
6	Engagement & Visualisation	●●●	●●●●● ... and looks better	<a href="#">Shiny UI</a>

An entirely personal, and very biased set of estimates!

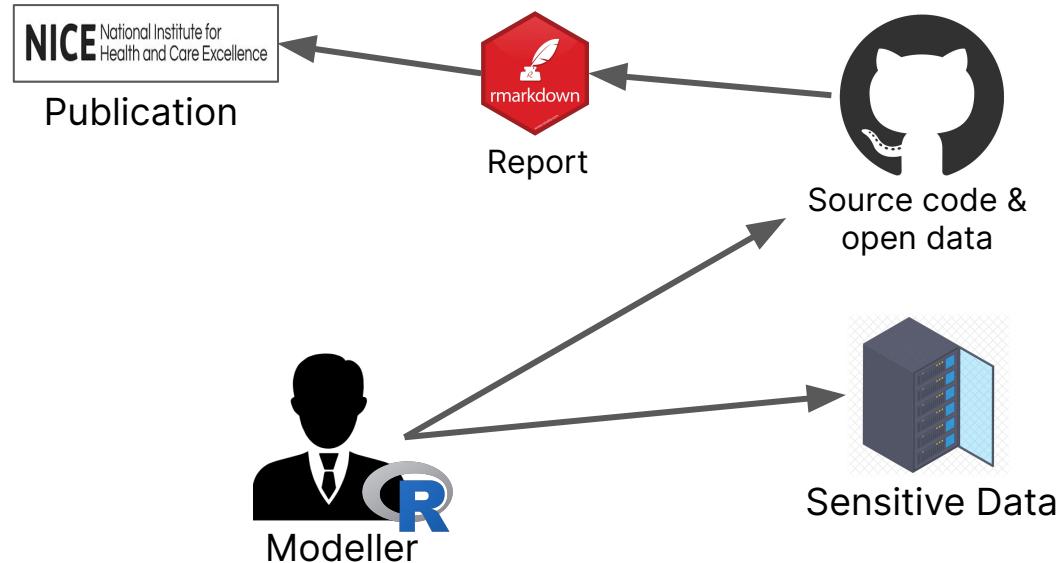


# External review options



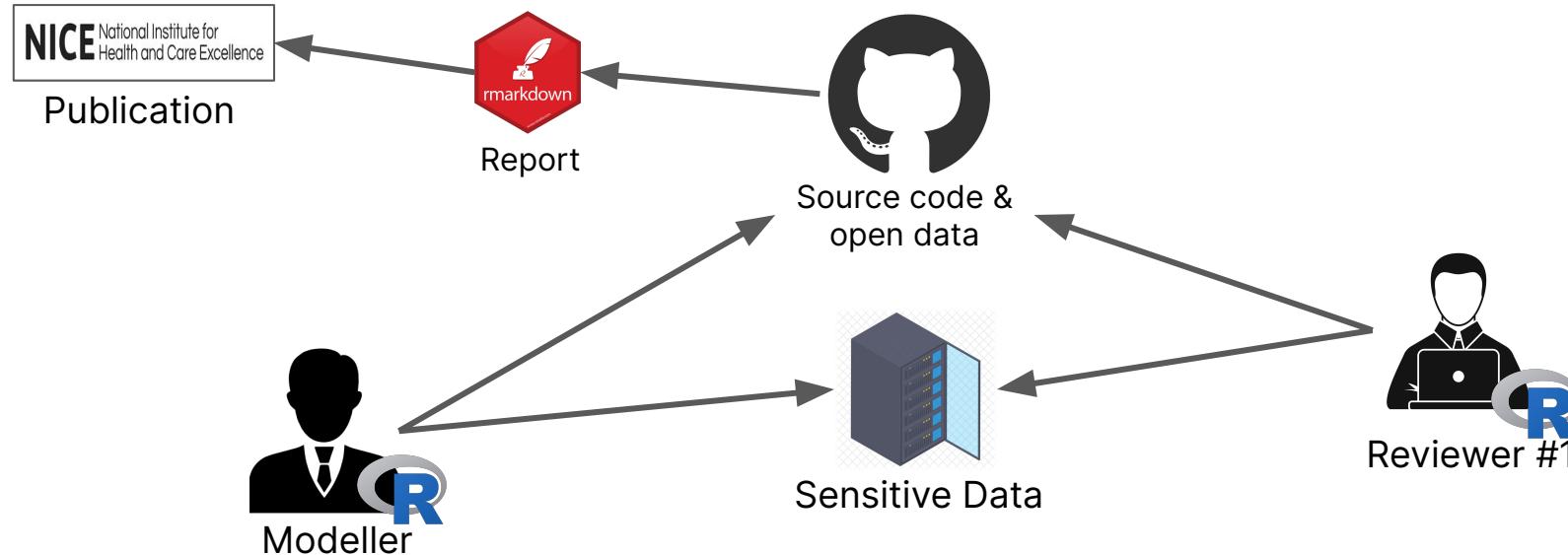


# External review options



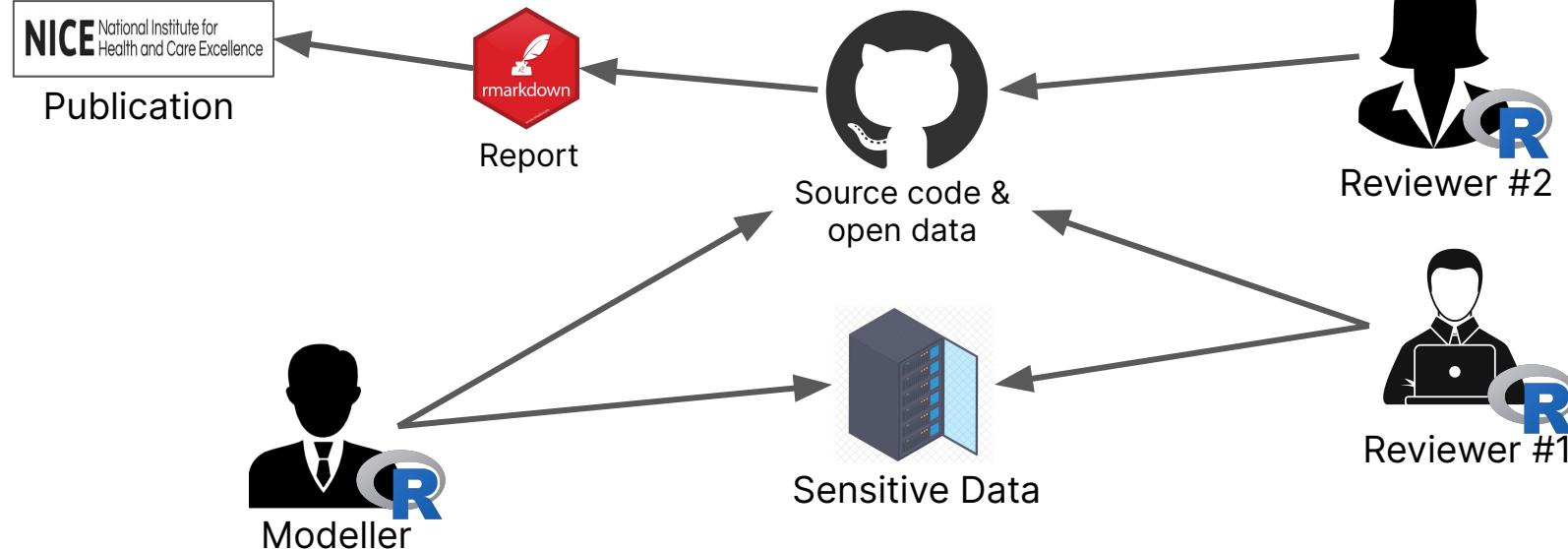


# External review options



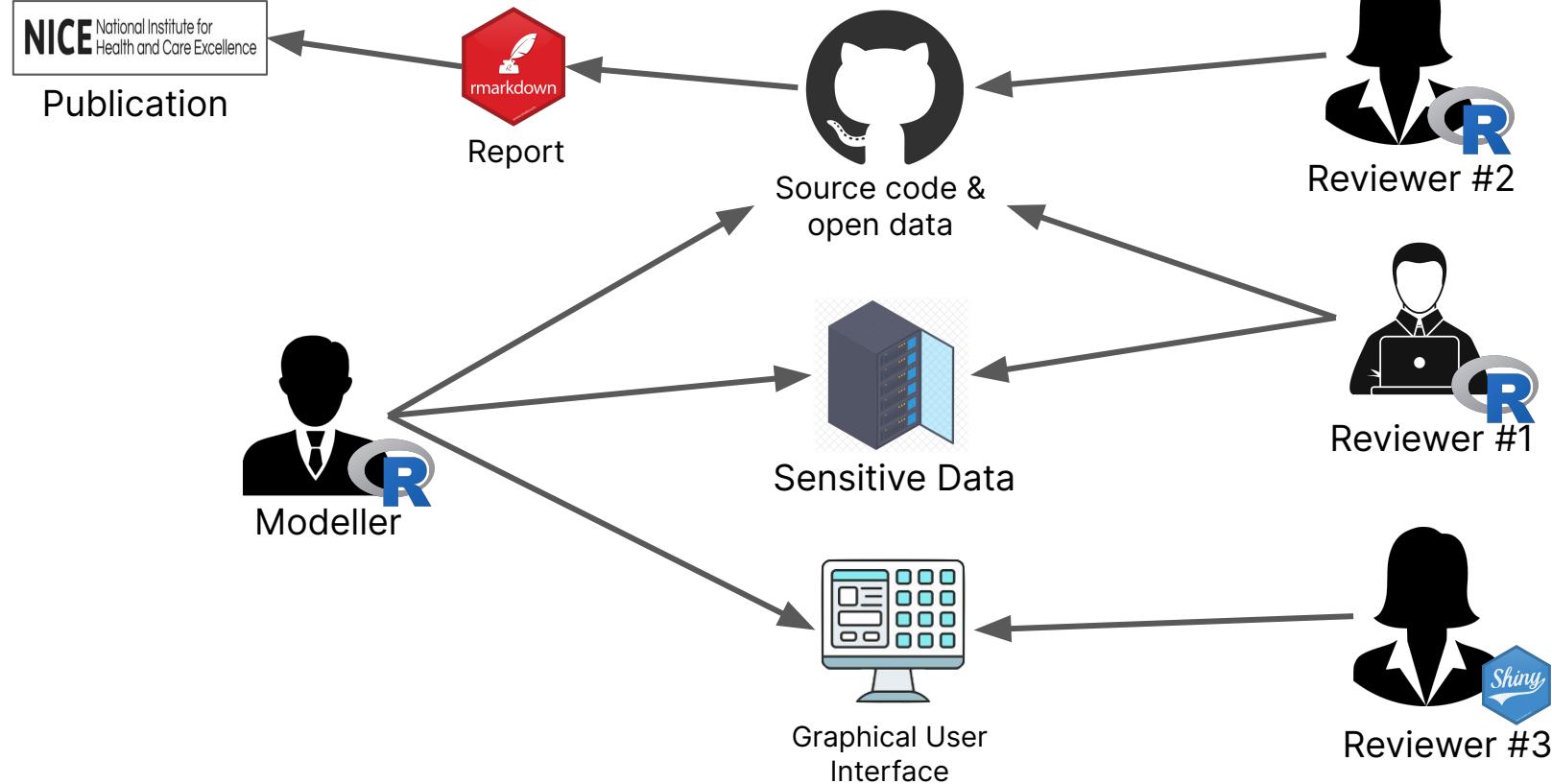


# External review options





# External review options





# MS Excel vs R (python / others)



			Comments	Link to Slide
1	Familiarity Barriers to entry	●●●●●	● Coding in R is hard	<a href="#">Teaching</a>
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6	Engagement & Visualisation	●●●	●●●●● ... and looks better	<a href="#">Shiny UI</a>

An entirely personal, and very biased set of estimates!

# Value of user-interfaces

Lex Fridman: *In a wikipedia page about the history of AI, which of the GPTs would they put [as the leap]?*

Sam Altman: *If I had to pick some moment [where AI went from not happening to happening] from what we have seen so far, I'd sort of pick Chat GPT ... **it wasn't the underlying model that mattered it was the usability of it** ... ease of use matters a lot, even if the base capability was there before.*



Sam Altman,  
CEO of OpenAI



# User-interfaces

Wellcome Open Research

Wellcome Open Research 2020, 5:69 Last updated: 05 JUL 2022

METHOD ARTICLE

## REVISED Making health economic models Shiny: A tutorial

[version 2; peer review: 2 approved]

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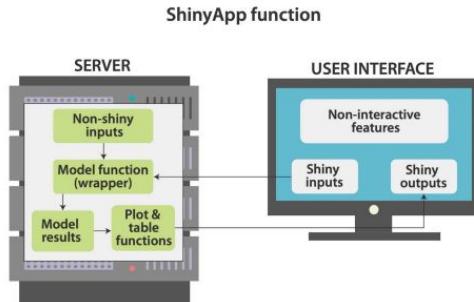
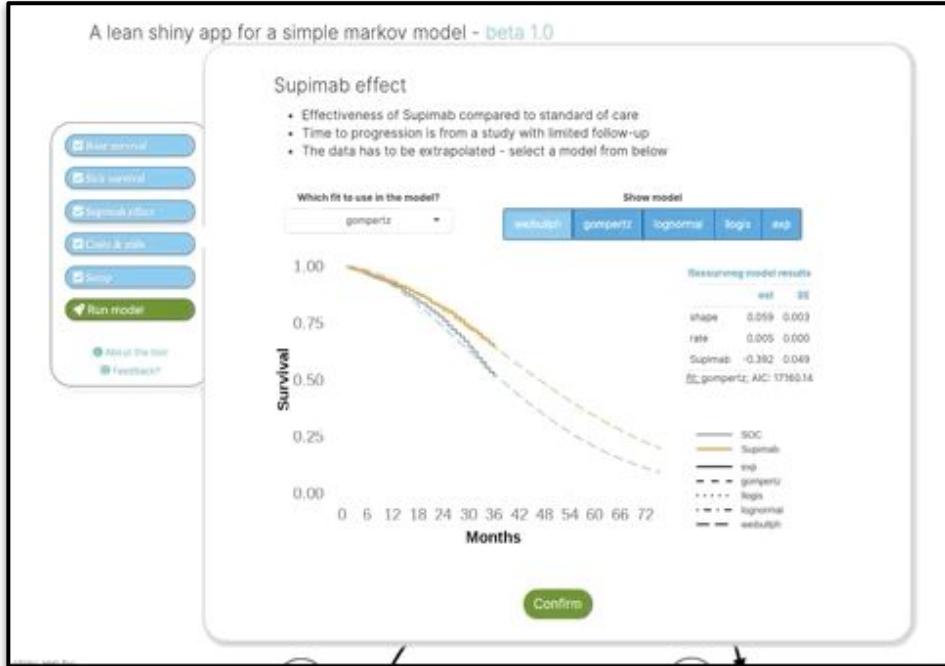


Figure 1. Diagram depicting how the Sick-Sicker app is structured.

**Smith RA** and **Schneider PP**. Making health economic models Shiny: A tutorial. *Wellcome Open Res* 2020, 5:69 (<https://doi.org/10.12688/wellcomeopenres.15807.2>)



<https://darkpeakanalytics.shinyapps.io/sadm-mk2/>



# Long term vision





# Challenges and Opportunities

## Challenges:

1. Skills gap
2. Wariness of disruption
3. Transparency (concerns around)
4. First movers ?

## Opportunities

1. Increased modelling efficiency (and ease of review)
2. Increased transparency (benefits of)
3. Potential for open source peer review
4. Establishing best practices & standardisation of methods



– Thanks from Sheffield –

[darkpeakanalytics.com/](http://darkpeakanalytics.com/)  
[contact@darkpeakanalytics.com/](mailto:contact@darkpeakanalytics.com/)  
[github.com/dark-peak-analytics](https://github.com/dark-peak-analytics)



DARK PEAK  
ANALYTICS



University of  
Sheffield



# Further resources

## Peer Reviewed Publications

**Smith, R.A.**, and Schneider, P.P. (2020). Making health economic models Shiny: A tutorial. *Wellcome Open Res*, 5, 69. <https://doi.org/10.12688/wellcomeopenres.15807.2>

**Smith, R.A.**, Schneider, P.P., and Mohammed, W. (2022). Living HTA: Automating Health Economic Evaluation with R. *Wellcome Open Res*, 7, 194. <https://doi.org/10.12688/wellcomeopenres.17933.2>

**Smith, R.A.**, Mohammed, W. and Schneider, P.P. (2023). Packaging cost-effectiveness models in R: A tutorial.  
Draft paper currently under review in [GoogleDoc](#)

Thokala, P, Srivastava, T, **Smith, R.A.**, Ren, S., Whittington, M.D., Elvidge, J., Wong, R., Uttley, L. (2023). Living Health Technology Assessment – Issues, Challenges and Opportunities. *Pharmacoeconomics*.

## Open Source Code

Source code for Shiny: [https://github.com/RobertASmith/healthecon\\_shiny](https://github.com/RobertASmith/healthecon_shiny)

Source code for Living HTA: <https://github.com/RobertASmith/plumberHE>

Source code for Packages: <https://github.com/dark-peak-analytics/sicksickerPack>